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This research examined how people perceive current site connection indicator icons and corresponding informational message statements found in six web browsers. The paper begins by providing some background of the research area as well as an overview of the site connection indicator icon and informational message statement. An online survey was also conducted, which asked participants to best match statements from the informational messages with site connection indicator icons. The main finding of this research was that based on the wording of the informational message statements, participants often chose corresponding site connection indicator icons in a manner similar to how web browser developers paired the site connection indicator icons and informational message statements. This provides evidence that web browser users perceive the informational message statements as generally matching the site connection indicator icons that represent them.

#### Headings:

Icons

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Usability

User perceptions

DOES THIS ICON TELL ME THIS SITE IS SECURE?: A STUDY OF USER  
PERCEPTIONS

by  
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Approved by

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## Introduction

For many people, the use of web browsers is an everyday occurrence. Web browsers are used to access the vast amount of content on the Internet for any number of reasons including for entertainment, work, and education. Because of this there is an increased need for awareness about web security. One method of web security feedback available to users is what this paper refers to as the site connection indicator icon — sometimes called the lock icon, the SSL<sup>1</sup> indicator, or the site identity icon in other literature — and the accompanying informational message statement when the site connection indicator icon is clicked on. This is a common method for users to gain basic web security information, so much so that Google Chrome's security team is in the process of updating these icons to increase user understanding (Greenberg, 2016).

Icons are used throughout a number of user interfaces. With the increasing usage of mobile devices with smaller screen sizes, it is reasonable to expect that designers are using icons to convey more information in less space. Icons have more often replaced text to convey possible actions, navigation, and information on these interfaces. Therefore, it is important to know if these icons are effectively conveying their intended meanings. If the user generally

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<sup>1</sup> Secure Sockets Layer (Symantec Corporation, n.d)

understands the icon meaning or if designers use icons with generally understood meanings, this contributes to the user interface being easier to use.

A web browser's site connection indicator icon provides useful information. This includes whether the connection to the website is secure or not. When the site connection indicator icon is clicked on, more detailed information about the connection status is shown in an informational message. However, despite the usefulness of the information, it is uncertain if users understand the different variations of the site connection indicator icons and their corresponding informational message statements determined by the web browser developers. Therefore, it is important to test these icons and statements for usability and user understanding.

This study examined how people perceive the intended meanings of current site connection indicator icons located in the address bars of six web browsers—Chrome, Edge, Firefox, Opera, Safari, and Vivaldi. In this context, the intended meanings refer to the informational message statements that define the site connection indicator icon and that appear when the site connection indicator icon is clicked on. Specific research questions include:

- What is the current state of the site connection indicator icons and the informational message statements being used in Chrome, Edge, Firefox, Opera, Safari, and Vivaldi?
- How do people perceive the connection between the site connection indicator icons and their corresponding informational message statements? More specifically, do site connection indicator icon

“definitions”—the informational message statements—match the icons that represent them?

These research questions were investigated by analyzing the site connection indicator icons and informational message statements and by conducting a survey about the user perceptions of these icons and statements.

## **Literature Review**

Previous research related to this study includes studies about icon interpretation as well as studies specifically about web browser security indicators.

### **Interpreting Icons**

This study focused on exploring the user's perception of a web browser icon's meaning. Icon meaning and understanding has been studied for a long time and research aspects include icon features and factors that influence icon understanding. The icon is a visual object that relays some information (Levioldi, Mussio, Protti, & Tosoni, 1993). The icon emphasizes the "general features shared by an entire class of objects" rather than a specific object (Zender, 2006).

Some factors influencing the effectiveness of an icon are "culture, familiarity, detail", "adherence to an archetype", and "clarity" (Caldwell, 2009). One study discussed that abstraction of the icon was preferred over having too much detail in the icon (Caldwell, 2009). However, if the icon detail reinforces the icon meaning, it does not detract from the icon's usability (Caldwell, 2009). Also it is important to use the correct strategy to implement meaning or object resemblance (Caldwell, 2009). In this study, the icons being used were designed with specific meanings in mind. This study looked into whether these meanings

were correctly implemented by assessing the user perceptions of the icon meanings as corresponding icons were chosen.

### **Web Browser Security Indicators**

Specific research relating to web browser security indicators have focused on the notice, recognition, and understanding of web browser security indicator icons both on desktop and mobile devices. They have also looked into the influence and manipulation of various features in order to improve notice, recognition, and understanding. Some refer to this research as a part of the “usability of security” (Pala & Wang, 2010).

One of the main challenges regarding web browser security indicator icons is that web security is often a secondary goal for users, following after the goal of completing the task at hand (Sobey, Biddle, van Oorschot, & Patrick, 2008). Users also often “ignore the browser chrome”, the part of the browser that includes the menu and address bar, meaning that any security indicators and the information they provide in the browser were also ignored (Sobey, Biddle, van Oorschot, & Patrick, 2008).

When users do pay attention to browser security indicators, they often looked at the “https”<sup>2</sup> or the padlock icon in the address bar to indicate a secure connection (Radke, Boyd, Brereton, & Nieto, 2010). The lock icon is usually looked at but users are not aware that the lock icon is clickable and will provide more information when clicked (Whalen & Inkpen, 2005). People also very rarely looked at the website certificate information (Whalen & Inkpen, 2005).

Previous research suggests that even if users recognize visual cues

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<sup>2</sup> “Hypertext Transfer Protocol Secure” (Google, n.d.)



indicating the site connection status, most users do not really understand what “https” is nor do they understand the more detailed information browsers provide such as the meaning of an SSL warning (Radke, Boyd, Brereton, & Nieto, 2010). Other research found that some users have a varied understanding of what “a secure web site” is (Flinn & Lumsden, 2005). Some thought this meant that the website, not the connection, was secure while others knew this referred to SSL/TLS<sup>3</sup> encryption and authentication (Flinn & Lumsden, 2005).

Besides the “https” and the padlock icon, color is also used as a browser security indicator, including within the address bar. Shin, Yao, & Rosi (2013) found that users preferred the traffic light warning over the padlock warning and no warning. This finding supports current common practices of using traffic light colors in web browser security indicator icons on a desktop. Other researchers have experimented with color in the web browser skin to indicate the site connection status (Maurer, De Luca, & Stockinger, 2011).

Biddle, van Oorschot, Patrick, Sobey, & Whalen (2009) experimented with an alternative SSL indicator and information messages that clearly differentiated the identity and confidentiality information of a website connection. For the most part, the alternative design was preferred over the Internet Explorer design used for comparison in terms of being easier to understand and being more confident about security (Biddle, van Oorschot, Patrick, Sobey, & Whalen, 2009). However, users overall preferred Internet Explorer because they believed that Internet Explorer looked better and the browser design and layout was more familiar to the users (Biddle, van Oorschot, Patrick, Sobey, & Whalen, 2009).

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<sup>3</sup> “Secure Sockets Layer / Transport Layer Security” (Symantec Corporation, n.d)

Felt et al. looked into the use of browser SSL warnings and believed that an ideal SSL warning would “empower users to make informed decisions” and “guide confused users to safety” (Felt, et al., 2015). However, they found that SSL warnings were often not understood by users, as other security indicators such as the “https” and the padlock icon often are (Felt, et al., 2015). They were able to develop a newer, easier to understand SSL warning for Google Chrome which was later used in Google Chrome version 37 (Felt, et al., 2015). However, while the study by Felt et al. focused only on the SSL warnings for Google Chrome, this study focused more broadly on site connection indicator icon variations and informational message statements from six different browsers.

Pala and Wang’s 2010 study suggested guidelines for the of security indicators in web browsers. They suggested that the security indicators should “(a) provide consistent and active messages, (b) provide simple, clear and short information, (c) minimize the impact of the browsing experience to user, and (d) appear where the user’s attention is focused” (Pala & Wang, 2010).

This study contributes to research relating to visually indicating web browser security information. While some studies in this research area created alternative implementations for various web browser security indicators, this study provides information about how users perceive a currently implemented web browser security indicator.

## **Current Site Connection Indicator Icons and Informational Message Statements**

### **Overview**

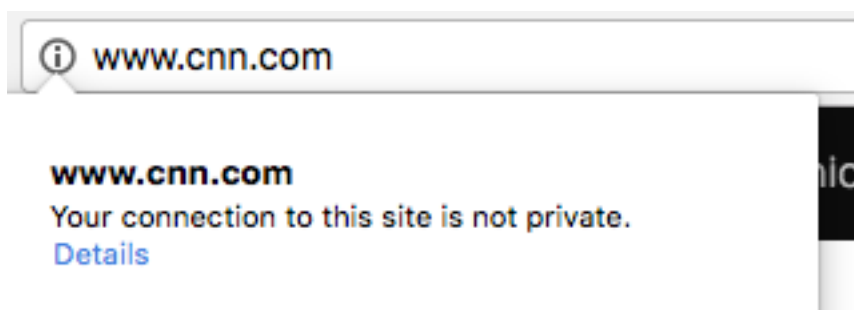
The first part of the research was an overview and analysis of the current state of the visual site connection indicator icon variations and the accompanying informational message statements from six web browsers. This provided a foundation for the content of the later survey. The variations of the site connection indicator icons and informational messages were pulled from the latest Windows 10 and Mac OS 10.11 web browser versions of Chrome, Edge, Firefox, Opera, Safari, and Vivaldi<sup>4</sup> available between September 2016 and October 2016. These web browsers are generally widely available either as a built-in native browser or as a free download from the developer's website.

The two main parts of the web browser that this research examined were the visual site connection indicator icons and the corresponding informational message statements that provide a brief text description of the connection status when the site connection indicator icons are clicked on. For the most part, the site connection indicator icon is located in the left-most part of the browser address bar. However, in previous versions of some browsers this was not

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<sup>4</sup> <https://www.google.com/chrome/browser/desktop/>; <https://www.microsoft.com/en-us/windows/microsoft-edge>; <https://www.mozilla.org/en-US/firefox/new>; [www.opera.com/download](https://www.opera.com/download); <https://support.apple.com/downloads/safari>; [https://vivaldi.com/download/?lang=en\\_US](https://vivaldi.com/download/?lang=en_US)

always the case (Bursztein, 2011).

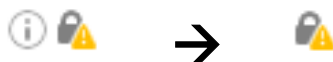


**Figure 1. Example of the site connection indicator icon and corresponding informational message statement, from Chrome**























Each browser uses a varying set of icons to represent the connection status. Multiple web pages were visited to collect as many unique icons and statements as possible, sometimes using the web developer's help web pages as a guide (AliceWyman, et al., n.d.) (Apple, n.d.) (Google, n.d.) (Microsoft, 2016) (Opera Software, n.d.). This also included visiting test pages instead of actual dangerous websites to find instances of icons that represent dangerous connection problems. The collected icons are shown below in Figure 3. Some caveats are listed below:

- These icons were modified to remove references to specific organizations.
- Some of these icons were cropped to only include the most defining components. For example, the “i” icon is always present in the address bar in Firefox, with or without a lock icon, depending on the connection status. After careful deliberation, the lock icon was determined as the defining component when both the “i” icon and lock icon appeared

together. Therefore, in the instances where there was a lock icon and an “i” icon, only the lock icon was used, without the “i” icon.



**Figure 2. Example of determining the defining components of this icon, taken from Firefox**

Browser	Icons
Chrome	    [Organization Name]
Edge	   Organization Name
Firefox	      Organization Name
Opera	   Organization Name
Safari	  Organization Name
Vivaldi	    Organization Name

**Figure 3. Site connection indicator icons, listed by browser**

The site connection indicator icon is accompanied by a corresponding informational message statement that provides a brief text description of the website connection status being represented. Because of their concise yet descriptive nature, these informational message statements, accessed by

clicking on the site connection indicator icon, are considered as the “definition” of the site connection indicator icon in this research. The collected informational message statements are shown below in Figure 5. Some caveats are listed below:

- If the same statement appeared more than once in a browser, it is only listed once in Figure 5 for that browser.
- Some informational messages contained a large amount of text. Only the defining text from the informational message was collected as the informational message statement. The determining factors included the placement and font format of the text.
- These statements were modified to remove references to specific organizations, website URLs, or browsers.

**Safari is using an encrypted connection to www.google.com.**

Encryption with a digital certificate keeps information private as it's sent to or from the https website www.google.com.



[Browser] is using an encrypted connection to [website URL].

***Figure 4. Example of determining the defining text from the informational message to use as the informational message statement, from Safari.***

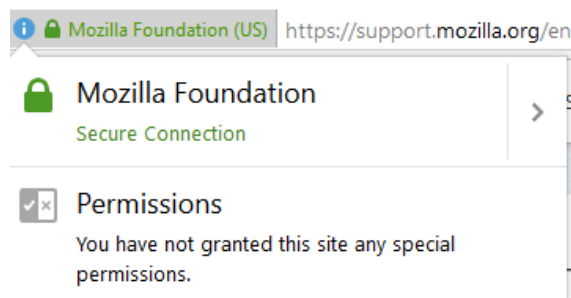
Browser	Informational Message Statements
Chrome	Your connection to this site is not private.
	Your connection to this site is private but someone on the network might be able to change the look of the page.
	Your connection to this site is private.
Edge	[Certificate authority] has identified this site as [website URL] Your connection to the server is encrypted.
	[Certificate authority] has identified this site as [organization information] Your connection to the server is encrypted.
	There's a problem with this website's security certificate. This might mean that someone's trying to fool you or steal any info you send to the server. You should close this site immediately.
Firefox	Connection is not secure
	Connection is not secure Parts of this page are not secure (such as images).
	Connection is not secure You have disabled protection on this page.
	Secure connection
	Secure connection
	[Browser] has blocked parts of this page that are not secure.
Opera	Unprotected connection
	Secure connection
	Secure and accredited connection
Safari	[Browser] is using an encrypted connection to [website URL].
Vivaldi	Your connection to this site is not private.
	Your connection to this site is private but someone on the network might be able to change the look of the page.
	Your connection to this site is private.

**Figure 5. Informational message statements, listed by browser**

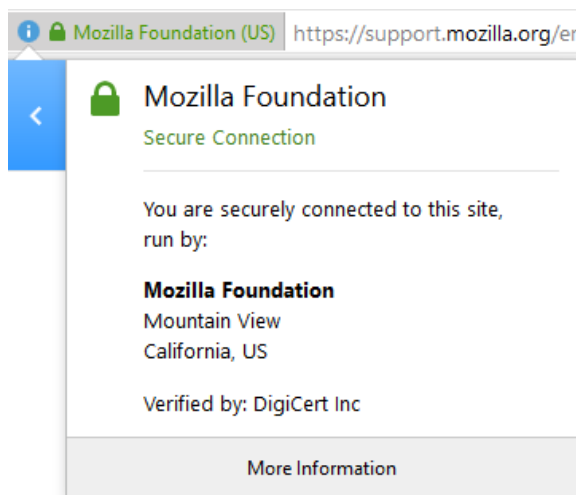
These browsers also often include second and sometimes third levels of information containing more details about the connection status. However, these second and third levels of information are not part of this research, since the first level — the informational message statement that appears when the site connection indicator icon is clicked on — provides the briefest description needed to understand the icon and is the easiest to access. Also, while some browser developers provide a detailed description of the icons on support documents, these did not provide an actual brief “label” or “title” for the icons (AliceWyman, et al., n.d.) (Apple, n.d.) (Google, n.d.) (Microsoft, 2016) (Opera Software, n.d.). Therefore, the detailed descriptions of the icons on the support documents were not used to “define” the site connection indicator icons in this research.



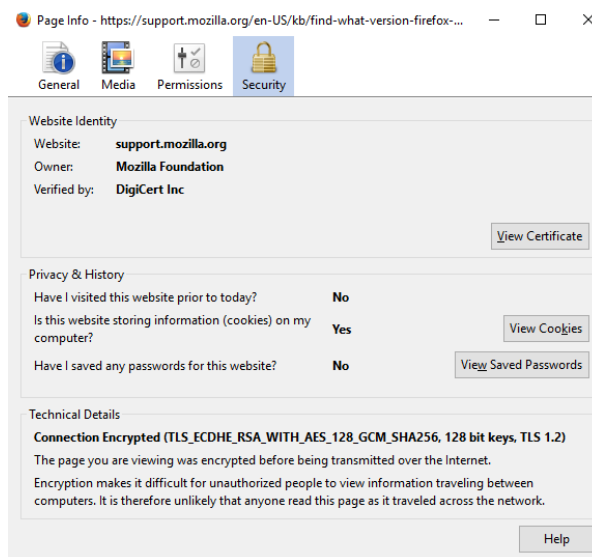
Level 1



Level 2



Level 3



**Figure 6. Example of three levels of connection status information in Firefox**

It is important to note that not all web browsers had the same number of icons and/or statements. For example, some browsers did not have an icon and/or statement for web pages with unsecured http<sup>5</sup> connections.

### **Categorization**

The site connection indicator icons and informational message statements gathered were grouped into five main categories by combining the similar icon/statement combinations from each browser. These categories were determined and described by the icon shape and color as well as the content of the informational message statements.

Current site connection indicator icons generally use the “traffic light” (plus gray) color scheme. As mentioned in the literature review, this seems to be generally understood and has been used in site connection indicator icons for a while.

For the most part, the basic shapes that comprise the site connection indicator icons are a circle—in the form of a globe or information icon—, a lock, and a triangle. A “slash” line, a shield shape, and organization name appear as well. In many cases, the site connection indicator icons contain multiple shape components to represent their meaning.







***Figure 7. Example of a multiple shape component icon, from Firefox***

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<sup>5</sup> “Hypertext Transfer Protocol” (Google, n.d.)

The information message statements themselves contain wording that differentiates the icon/statement combinations between the five categories. The key words are some variation of “is secure/encrypted/private” and “is not secure/encrypted/private.” Additional details help to sort the combinations further.







The five categories of the site connection indicator icon/informational message statement combinations are shown below in Figures 8, 9, 10, 11, and 12. Category 1 contains combinations that indicate a connection that is not secure. The icons tend to be gray in color and circular in shape. Category 2 contains combinations that indicate a secure connection, with icons that tend to be green or gray in color, and appear in the shape of a lock. Category 3 contains combinations that indicate a secure connection that has had extra validation. Category 3 icons tend to be green in color and are composed of a lock shape in addition to the organization’s name. Category 4 contains combinations that indicate a connection that is not secure and that may have major problems such as website certificate errors. The icons tend to contain the color red and are composed of various shapes. Category 5 combinations tend to indicate a secure connection that may have minor issues such as parts of the content not being secure. The icons for Category 5 seem to either be gray and circular or be composed of both a lock and a triangle and contain 2 colors, including the color gray.

Category 1	
	Your connection to this site is not private.
	Connection is not secure
	Unprotected connection
	Your connection to this site is not private.





**Figure 8. Category 1 combinations**

Category 2	
	Your connection to this site is private.
	[Certificate authority] has identified this site as [website URL]  Your connection to the server is encrypted.
	Secure connection
	Secure connection
	[Browser] is using an encrypted connection to [website URL].
	Your connection to this site is private.





**Figure 9. Category 2 combinations**

Category 3	
 [Organization Name]	Your connection to this site is private.
 Organization Name	[Certificate authority] has identified this site as [organization information]
 Organization Name	Secure connection
 Organization Name	Secure and Accredited Connection
 Organization Name	[Browser] is using an encrypted connection to [website URL].
 Organization Name	Your connection to this site is private.

**Figure 10. Category 3 combinations**

Category 4	
	Your connection to this site is not private.
	There's a problem with this website's security certificate. This might mean that someone's trying to fool you or steal any info you send to the server.  You should close this site immediately.
	Connection is not secure  You have disabled protection on this page.
	Your connection to this site is not private.

**Figure 11. Category 4 combinations**

<b>Category 5</b>	
	Your connection to this site is private but someone on the network might be able to change the look of the page.
	Your connection to this site is private but someone on the network might be able to change the look of the page.
	Connection is not secure  Parts of this page are not secure (such as images).
	Secure connection  [Browser] has blocked parts of this page that are not secure.

**Figure 12. Category 5 combinations**

The six web browsers also used three main terms to indicate a secure or not secure website connection status in the informational message statements. These terms are “encrypted”, “private”, and “secure”. Chrome and Vivaldi use “private”. Firefox and Opera use “secure”. Edge and Safari use “encrypted”.

### **Consistency**

While examining of the site connection indicator icons and information message statements, it quickly became obvious that there was a lack of consistency in some aspects of this method of indicating web browser security. The icons and statements used to represent secure connections in Category 2 and Category 3 were fairly consistent. However, other aspects were not consistent. To describe a few inconsistencies:

- Not all browsers had the same number of site connection indicator icon/informational message statement combinations to describe the connection status. For example, Safari only uses two combinations. On the web browser support documentation (Apple, n.d.), Safari details that if there is a lock icon, the connection is secure but does not mention anything about the meaning of a lack of an icon. This leads to only an inference that if there is no icon, the connection is not secure for some reason. On the other hand, Firefox uses six combinations to describe a range of connection statuses.
- As mentioned earlier, the six web browsers differ in how they refer to a secure connection in the informational message statements. Two browsers use the term “encrypted”, two browsers use the term “private”, and two browsers use the term “secure”.
- Icons in Category 4 are not consistent in shape between browsers, although most of the icons are consistently red or contain red.
- The level of detail in the informational messages as well as how the messages are formatted differs greatly depending on the browser and the information being conveyed.

These inconsistencies led to a need to establish “rules” in order to be able to test these site connection indicator icons and informational message statements in a survey.

## **User Perceptions of Site Connection Indicator Icons and Informational Message Statements**

The second part of this research involved collecting data from a Qualtrics<sup>6</sup> survey about how web browser users currently perceive the meaning conveyed by the informational message statements by matching the informational message statements with site connection indicator icons.

### **Methods & Participants**

An online Qualtrics survey was used to gather feedback about the site connection indicator icons and informational message statements. The survey description and link were sent out in an email to a convenience sample made up of recipients of a few UNC Chapel Hill emailing lists. Participants were asked to take the survey only if they were over 18 years old. The survey was anonymous and no identifying information was recorded. These methods allowed for the collection of numerous responses from a population in a short amount of time.

### **Survey Content**

The site connection indicator icons and the informational message statements examined in the previous section were used as the basis for this survey. In general, because of the inconsistencies of the icons and statements, some “rules” were made to create a usable set of icons and statements to test.

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<sup>6</sup> [www.qualtrics.com](http://www.qualtrics.com)



Since some icons were very similar, in some cases only one icon was used to represent the set of very similar icons. In other cases, multiple similar icons were included. This was determined by looking at the overall similarity in the shape, components, and color of the icons.



***Figure 13. Example of picking one icon to include in the survey from a set of very similar icons***


















***Figure 14. Example of two similar icons with differing background colors. Both icons were included in the survey***

The same “rules” for determining which icons to include in the survey were generally used to determine which informational message statements to include in the survey. Therefore, for statements that had the exact same wording, only one instance of the statement was included in the survey.

Another “rule” was that since some browsers did not include an icon and/or descriptive statement in cases when other browsers did, a “No statement” question and a “No icon” answer choice should be included in the survey. This combination was considered as its own category of icon/statement combinations when summarizing the results.

Based on these “rules” the following icons and statements were used in the survey as show in Figures 15 and 16.

Icons			
			
			 Organization Name
			 Organization Name
			(No Icon)

**Figure 15. Final set of icons used in the survey (Note: a green lock cropped from Edge’s extended validation icon was actually used to represent ‘green lock icons’ because of its higher image resolution)**

<b>Statements</b>	
<p>Connection is not secure</p> <p>Parts of this page are not secure (such as images).</p>	<p>There's a problem with this website's security certificate. This might mean that someone's trying to fool you or steal any info you send to the server. You should close this site immediately.</p>
<p>Your connection to this site is not private.</p>	<p>[Browser is using an encrypted connection to [website URL].</p>
<p>Connection is not secure</p>	<p>Secure Connection</p>
<p>Unprotected connection</p>	<p>Your connection to this site is private.</p>
<p>[Certificate authority] has identified this site as [website URL]</p> <p>Your connection to the server is encrypted.</p>	<p>Secure Connection</p> <p>[Browser] has blocked parts of this page that are not secure.</p>
<p>Your connection to this site is private but someone on the network might be able to change the look of the page.</p>	<p>Secure and accredited connection</p>
<p>Connection is not secure</p> <p>You have disabled protection on this page.</p>	<p>[Certificate authority] has identified this site as [organization information]</p> <p>Your connection to the server is encrypted.</p>
<p>[No statement]</p>	

**Figure 16. Final set of statements used in the survey**

### **Survey Format**

The survey began by asking participants demographic information such as age range and highest education completed. The survey also asked participants

about which web browsers they have used, which web browser they primarily use, and how often they use a web browser on a typical day. The last question in the first part of the survey was to rank the terms “encrypted”, “private”, and “secure” in order of preference. These questions had predefined answer choices.

The second part of the survey asked participants to best match statements from the informational messages with a site connection indicator icon. These were all multiple-choice questions, each with the same answer choices in the same order. The answer choices were listed predominantly by color. For each question, only the statement from the informational message was changed. Also, the statements were given in a random order for each participant, as determined by the Qualtrics survey software. These questions were used to provide insights into which icons users seemed to expect given the “definition” of the connection status. An example of a question from the second part of the survey is shown below in Figure 17.

Which icon do you think best matches the following statement?

Secure and accredited connection

<input type="radio"/> ⓘ	<input type="radio"/> ⚠
<input type="radio"/> 🌐	<input type="radio"/> 📺
<input type="radio"/> 🌐	<input type="radio"/> 🧑
<input type="radio"/> 🔒	<input type="radio"/> 🔒
<input type="radio"/> 🔒	<input type="radio"/> 🔒 Organization Name
<input type="radio"/> ✍	<input type="radio"/> 🔒
<input type="radio"/> ⚠	<input type="radio"/> 🔒 Organization Name
<input type="radio"/> ⚠	<input type="radio"/> No icon

>>

Powered by Qualtrics

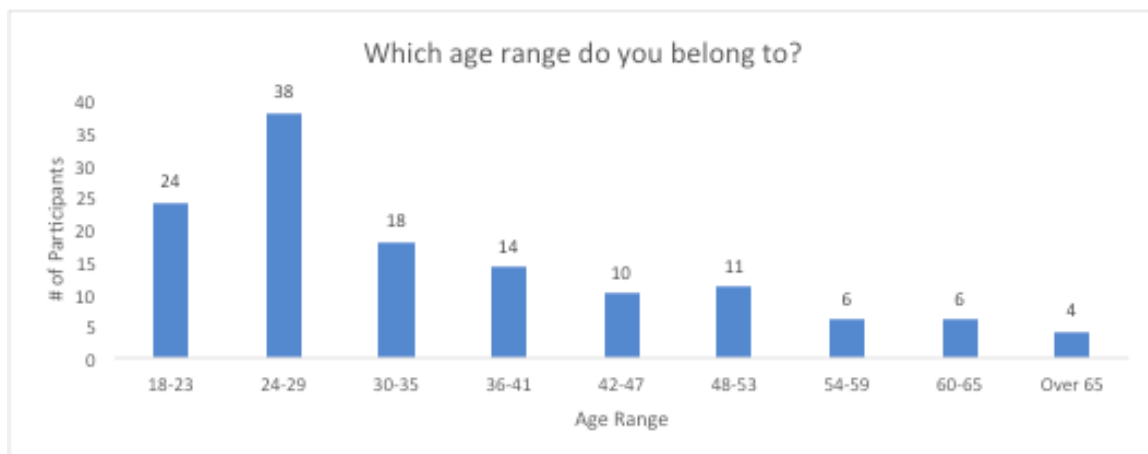
**Figure 17. Example of one of the survey questions, illustrating the question and answer formats**

## Results

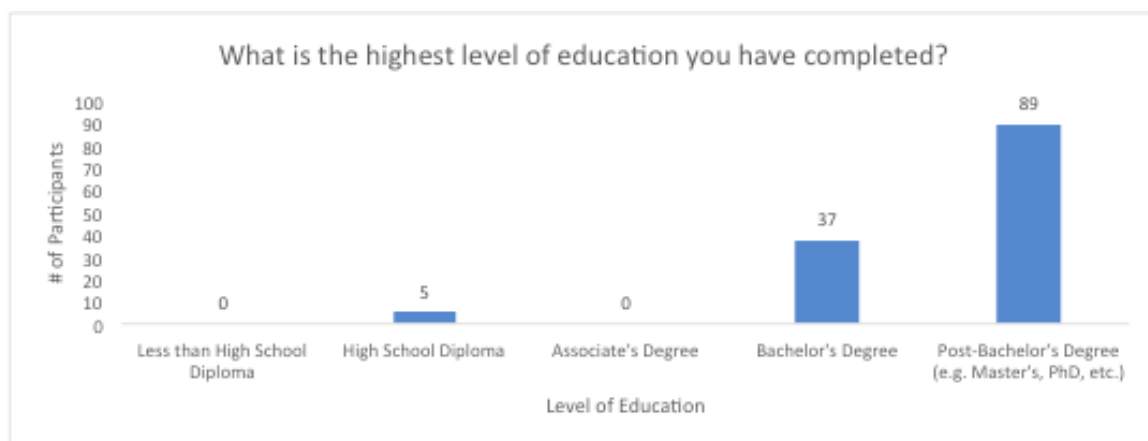
The survey was open for one week. After removing incomplete and unfinished responses, 131 responses were analyzed. The summarized results are based on these 131 responses.

Although the survey was distributed to a convenience sample within a university, there were participants from each age group. The largest age group was “24-29” (29%), followed by “18-23” (18.3%). The smallest age groups were “Over 65” (3.1%), “54-59” (4.6%), and “60-65” (4.6%). Only three of the five education levels were represented: 3.8% of participants indicated “High School

Diploma”, 28.2% of participants indicated “Bachelor’s Degree”, and 67.9% of participants responded “Post-Bachelor’s Degree (e.g. Master’s, PhD, etc.)”. The results of the age range and education level questions are shown in the figures below.

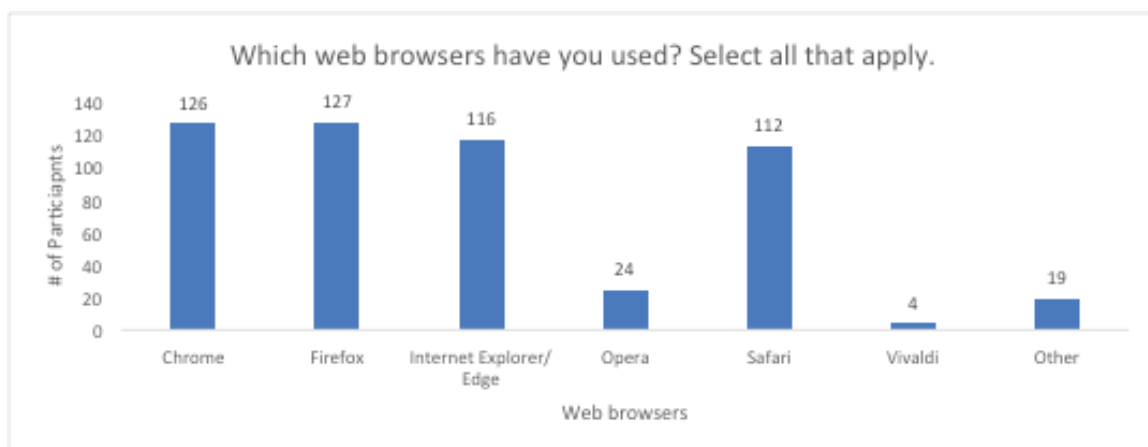


**Figure 18. Responses to "Which age range do you belong to?"**

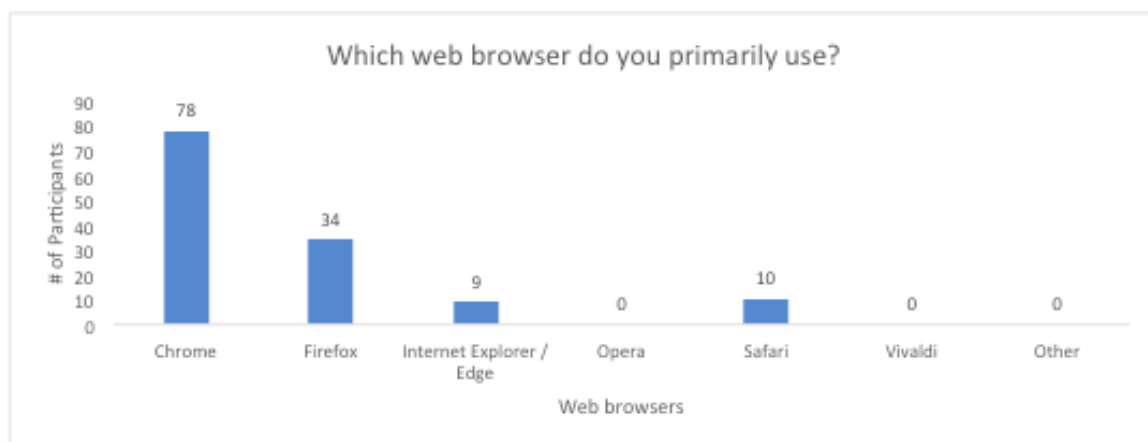


**Figure 19. Responses to "What is the highest level of education you have completed?"**

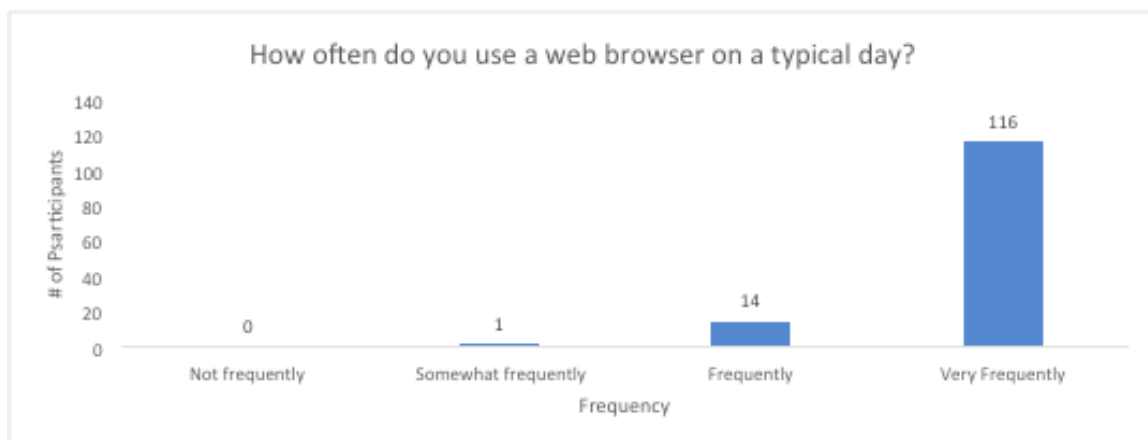
Most people had used Chrome (96.2%), Firefox (96.9%), Internet Explorer/Edge (88.5%), and Safari (85.5%) before. Over half of the participants used Chrome as their primary browser (59.5%). Overwhelmingly, the majority of the participants indicated that they use a web browser “very frequently” on a typical day (88.5%).



**Figure 20. Responses to "Which web browsers have you used? Select all that apply."**



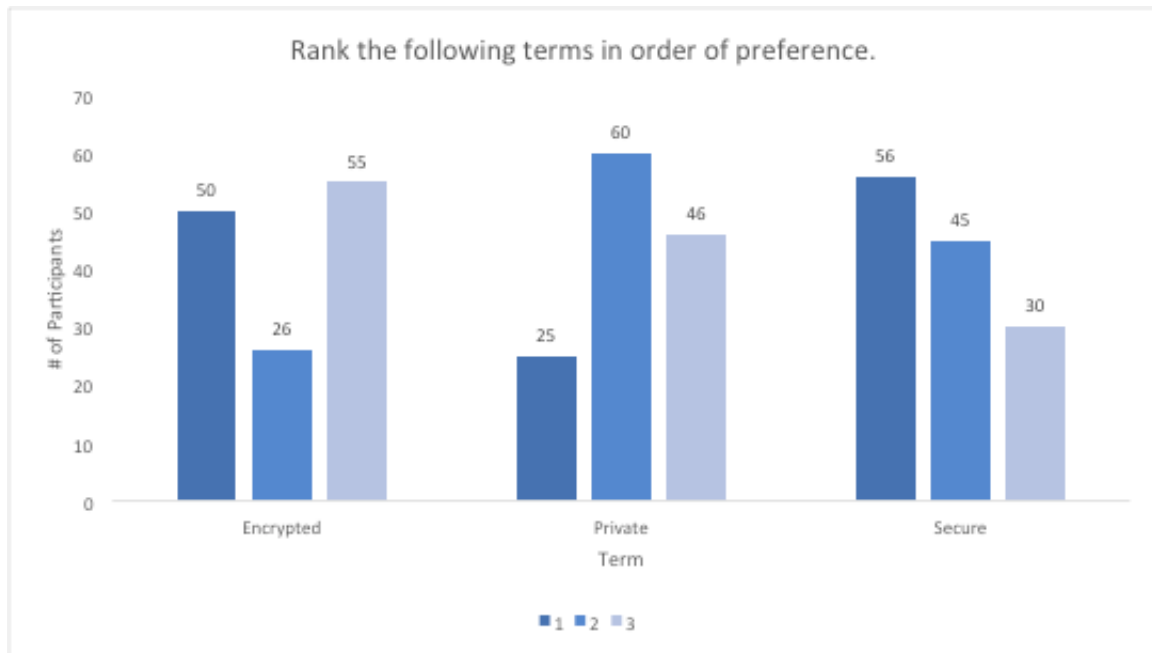
**Figure 21. Responses to "Which web browser do you primarily use?"**



**Figure 22. Responses to "How often do you use a web browser on a typical day?"**

Looking at the rankings between the three terms "encrypted", "private", and "secure" showed an interesting result. Overall, "secure" was most often ranked first (42.7%), "private" was most often ranked second (45.8%), and "encrypted" was most often ranked third (42%). However, the difference between the number of participants that ranked "encrypted" first and the number of participants that ranked "encrypted" third was small. The difference between the number of participants that ranked "encrypted" first and the number of participants that ranked "secure" first was also small.





**Figure 23. Responses to "Rank the following terms in order of preference."**














































An overview of the results of the second part of the survey, which asked participants to best match the statement from the informational message to an icon, is shown in Figure 24 below as a matrix between the questions' statements and the icon answer choices.






















																	(no icon)
Connection is Not Secure	4	0	1	0	0	56	11	6	27	23	0	0	0	0	0	3	
Your connection to this site is not private.	3	3	10	0	1	38	19	5	19	18	1	0	0	0	0	14	
Your connection to this site is private but someone on the network might be able to change the look of the page.	6	1	1	2	0	2	41	1	11	5	36	1	2	0	1	21	
Unprotected connection	2	1	2	0	0	37	8	18	18	35	0	0	0	0	0	10	
[Certificate authority] has identified this site as [website URL]. Your connection to the server is encrypted.	4	1	3	3	13	0	0	3	1	0	4	34	22	8	27	8	
Connection is Not Secure Parts of this page are not secure (such as images).	1	0	0	0	0	32	46	7	24	9	9	0	0	0	0	3	
Connection is Not Secure. You have disabled protection on this page.	3	0	0	0	0	39	18	19	19	27	4	0	0	0	0	2	
There's a problem with this website's security certificate. This might mean that someone's trying to fool you or steal any info you send to the server. You should close this site immediately.	0	0	0	0	0	6	13	37	61	9	1	0	0	0	0	4	
[Browser] is using an encrypted connection to [website URL].	3	3	2	6	16	0	6	1	3	0	5	41	12	16	8	9	
Secure Connection	0	3	0	12	25	0	2	0	0	0	2	58	3	22	2	2	
Your connection to this site is private.	2	1	0	14	24	1	2	1	1	0	1	40	4	21	6	13	
Secure Connection [Browser] has blocked parts of this page that are not secure.	1	0	0	0	0	5	42	30	23	1	25	3	0	0	0	1	
Secure and accredited connection	0	3	1	3	14	0	2	0	0	0	1	31	29	18	25	4	
[Certificate authority] has identified this site as [organization information] Your connection to the server is encrypted.	4	1	2	5	9	0	2	0	1	0	1	18	30	5	47	6	
[No statement]	10	1	3	1	1	1	1	2	2	0	0	0	0	0	0	109	

**Figure 24. Responses to "Which icon best matches the following statement? [statement]", showing all statements and icon choices**

However, a different approach to displaying the results gave clearer insights. Below in Figure 25, the statements are shown with their “actual response” icon(s), based on the site connection indicator icon/informational message statement combinations in Figures 8, 9, 10, 11, and 12, as well as the

top three icons participants believed best matched each statement. If there was a tie for third place, only one icon from the tie is shown.

Statement	Actual Response(s)	Most popular response (#)	Second most popular response (#)	Third most popular response (#)	Top 3 most popular responses as percent of total responses
Connection is not secure		 (56)	 (27)	 (23)	80.9%
Your connection to this site is not private.	   	 (38)	 (19)	 (19)	58%
Your connection to this site is private but someone on the network might be able to change the look of the page.	 	 (41)	 (36)	(no icon) (21)	74.8%
Unprotected connection		 (37)	 (35)	 (18)	68.7%
[Certificate authority] has identified this site as [website URL] Your connection to the server is encrypted.		 (34)	 Organization Name (27)	 Organization Name (22)	63.4%
Connection is not secure Parts of this page are not secure (such as images).		 (46)	 (32)	 (24)	77.9%
Connection is not secure You have disabled protection on this page.		 (39)	 (27)	 (19)	64.9%
There's a problem with this website's security certificate. This might mean that someone's trying to fool you or steal any info you send to the server. You should close this site immediately.		 (61)	 (37)	 (13)	84.7%
[Browser is using an encrypted connection to [website URL].	 	 (41)	 (16)	 (16)	55.7%
Secure Connection	  Organization Name	 (58)	 (25)	 (22)	80.2%

Statement	Actual Response(s)	Most popular response (#)	Second most popular response (#)	Third most popular response (#)	Top 3 most popular responses as percent of total responses
Your connection to this site is private.	    Organization Name Organization Name	 (40)	 (24)	 (21)	64.9%
Secure Connection [Browser] has blocked parts of this page that are not secure.		 (42)	 (30)	 (25)	74%
Secure and accredited connection	 Organization Name	 (31)	 Organization Name (29)	 Organization Name (25)	64.9%
[Certificate authority] has identified this site as [organization information] Your connection to the server is encrypted.	 Organization Name	 Organization Name (47)	 Organization Name (30)	 (18)	72.5%
[No statement]	(no icon)	(no icon) (109)	 (10)	 (3)	93.1%

**Figure 25. Comparing actual matches to the participants' top three responses**

Looking at the results, it is immediately clear that based on the statement “definitions”, participants seem to generally match Category 1 statements—“Connection is not secure”, “Your connection to this site is not private”, and “Unprotected Connection”—with Category 4 icons rather than Category 1 icons, although it is important to note that the statement “Your connection to this site is not private” is also used in Category 4. This finding may indicate a need to modify the wording of the statements in order for users to understand the difference between a connection that is not secure because there is no encryption and a connection that is not secure because of major errors, such as a website certificate error.

Overwhelmingly, participants chose the answer choice “No icon” when

asked to select an icon that best represents “No statement”. This may mean that participants chose the option that “just made sense.” However, this may also indicate that the lack of an icon provides no information about the connection status, whether it is secure or not.

Overall, for about 40% of the statements, the top answer choice given by participants exactly matched the actual icon(s) designated by the developers. For about 73.3% of the statements, at least one of the top three answers chosen by participants matched the actual icon(s). For about 80% of the statements, the top answer choice was in the same category (Figures 8, 9, 10, 11, and 12) as the actual icon(s). For about 86.7% of the statements, at least one of the top three answers given was in the same category as the actual icon(s). On average, the top three answer choices represented about 71.9% of the responses for a statement. These results show that based on the wording of the statements, participants often chose corresponding icons in a manner similar to how web browser developers paired the site connection indicator icons and informational message statements.

## Research Limitations

One of the main limitations of this research is that all the possible site connection indicator icons and informational message statements from the six browsers may not have been found. Some may only appear under rare circumstances or they may just not have been found in the search phase.

Another limitation was a lack of consistency in the number of combinations found in each browser as well as in how the icons and statements are formatted. This made it difficult to create a usable set of icons and statements to test.

Because of the inconsistencies, some assumptions were made and “rules” were created in order to create testable content. However, these assumptions may have been incorrect and the “rules” may not have been ideal. For example, the website URL and organization name was often parsed from the informational message statements tested in the survey based on the assumption that this piece of information was not especially useful. This may have been an incorrect assumption and could possibly be tested in future research.

The survey was given to a convenience sample, which may not be representative of the general population as a whole. Proof of this is that 67.9% of the participants responded that they had completed a Post-Bachelor’s degree. A different sampling method would have led to a better representation of the perceptions of the general population.

Lastly, this research was restricted to only testing content that already exists. Studying how participants match current informational message statements and site connection indicator icons is important but it does not show the participants' perceptions unbounded by predefined statements and/or icons. An alternative method might have been to provide a site connection indicator icon and ask participants to write down a brief description of what they think the icon means.

## Conclusion

The purpose of this research was to gain insights into how people perceive current site connection indicator icons and corresponding informational message statements found in six web browsers by examining the current state of the site connection indicator icons and informational message statements as well as conducting a survey to provide data about how people match informational message statements with site connection indicator icons.

The examination of the current state of site connection indicator icons and corresponding informational messages statements led to the organization of the collected site connection indicator icons and informational message statements into five main categories, defined by icon color and shape as well as the content of the informational message statements. The issue of a lack of consistency in indicating web browser security using the site connection indicator icons and corresponding informational messages was also discussed.

The major finding of the research was that based on the wording of the informational message statements in the survey questions, participants more often chose corresponding icons in a manner similar to how web browser developers paired the site connection indicator icons and informational message statements in the web browsers. This provides evidence that web browser users perceive the informational message statements as generally matching the site



connection indicator icons that represent them. However, the most miscommunicated site connection indicator icon/informational message statement combinations were those that indicated an http connection that was not secure.

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